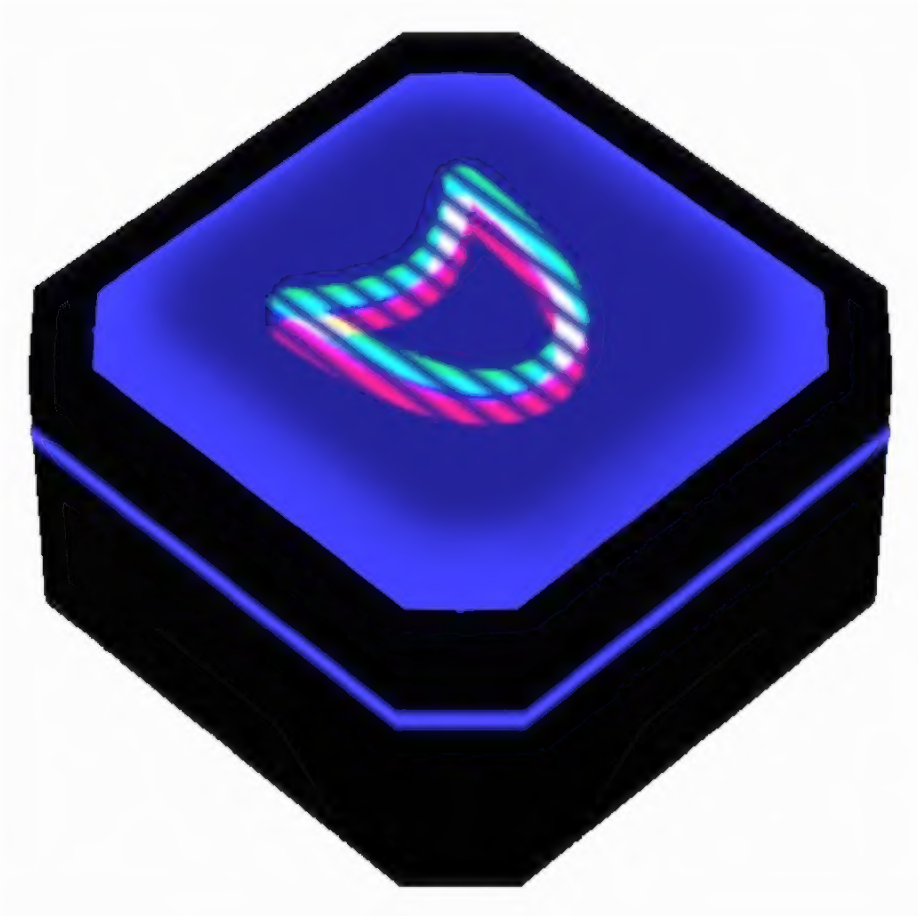
What is a Logic gates and where used in PLC ?

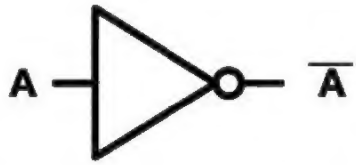
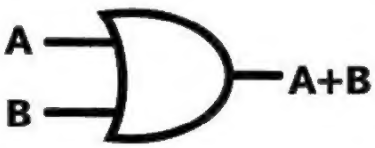
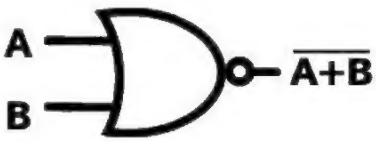
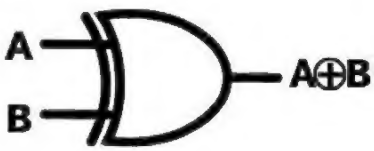
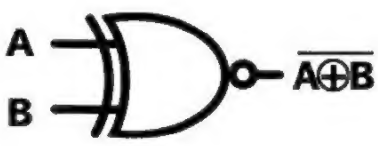


Logic gates are the fundamental building blocks of digital circuits that perform basic logical operations on one or more binary inputs (0 or 1) to produce a single binary output. They are found in nearly all electronic devices, including computers, smartphones, and memory systems.

The operation of logic gates is based on Boolean algebra, where inputs and outputs are represented as either "true" (1) or "false" (0).

- Common Types of Logic Gates:

There are seven basic logic gates, each with a specific symbol and rule for determining the output based on its inputs.

Name	Symbol & notation	Explanation
NOT		The inverter NOT simply accepts an input and **outputs the opposite**.
AND		**All inputs** must be positive (1) before the output is positive (1 or ON)
NAND *Not AND		Same as AND, but the **outcome is the inverse** (NOT). So, perform **AND first**, **then apply NOT** to the output.
OR		**At least** one input must be positive (1) to give a positive output (1 or ON). **All** inputs could also be positive.
NOR *Not OR		Same as OR, but the **outcome is the inverse** (NOT). So, perform **OR first**, **then apply NOT** to the output.
XOR *eXclusive OR		**Only one** input can be positive (1) to give a positive output (1 or ON). If both are positive, the output is negative (0 or OFF)
XNOR *eXclusive Not OR		**All inputs** must be the same (either high or low) for a positive output (1). Otherwise, the output is negative (0 or OFF)

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- Universal Gates:
The NAND and NOR gates are known as universal logic gates because any other logic function (AND, OR, NOT, etc.) can be constructed using only one type of these gates. This property simplifies the design and manufacturing of complex integrated circuits (ICs).
- Applications:
Logic gates are essential components in modern technology.
- They are combined in complex ways to create:
Microprocessors for general computing tasks.
Memory devices for storing data.
Arithmetic circuits like adders and subtractors.
Control systems in industrial automation and everyday appliances.
You can experiment with how different logic gates work using a free online Logic.ly demo or other simulators.

https://logic.ly/demo/

- Logic gates and PLC:

Logic gates are the fundamental building blocks used in Programmable Logic Controllers (PLCs) to make decisions based on binary inputs (True/1 or False/0) and produce a corresponding output. In most PLC programming (specifically ladder logic), these gates are implemented using simple relay logic symbols like contacts and coils.

- Implementation in Ladder Logic:

PLCs primarily use ladder logic (LD) for programming logic functions due to its resemblance to traditional electrical relay circuits, making it intuitive for electricians and engineers.

- The basic logic gates are implemented as follows:

* AND Gate:

Corresponds to series contacts. Both input A and input B must be true (closed) for the output to be true (energized).

* OR Gate:

Corresponds to parallel contacts. Either input A or input B (or both) must be true (closed) for the output to be true.

* NOT Gate (Inverter):
Corresponds to a normally-closed contact. The output is true if the input is false (open), and vice versa.
* NAND Gate:
An AND gate followed by a NOT gate. In ladder logic, this can be represented by two normally-closed contacts in series, which means the output is only false when both inputs are true.
* NOR Gate:
An OR gate followed by a NOT gate. In ladder logic, this can be represented by two normally-closed contacts in parallel, meaning the output is only true when both inputs are false.
* XOR Gate (Exclusive OR):
The output is true if only one, but not both, of the inputs is true. This requires a combination of series and parallel contacts (e.g., Input A NO in series with Input B NC, in parallel with Input A NC in series with Input B NO).
* XNOR Gate (Exclusive NOR):
The output is true if both inputs are the same (both true or both false).

This is the inverse of the XOR gate.

- Role in PLC Programming:

Logic gates are used to process input signals from real-world devices (like limit switches, sensors, and pushbuttons) and determine the appropriate response for output devices (like motors, lights, or valves). This allows engineers to design complex control sequences and automation solutions, forming the basis for both simple and intricate industrial processes. Other PLC programming languages like Functional Block Diagrams (FBD) use dedicated graphical symbols for each logic gate. Programmable Logic Controllers (PLCs) use various integrated circuits (ICs) internally for their processing, but they primarily execute logic functions using software-based logic rather than specific, user-replaceable logic gate ICs like the 7400 series. The PLC's CPU runs a program (often in ladder logic, a graphical language that mimics traditional relay circuits) which implements the desired Boolean logic functions (AND, OR, NOT, etc.).

- **PLC Internal Components (ICs):**

PLCs are essentially rugged, specialized computers designed for industrial environments. Key ICs used within a PLC's hardware include:

1. Microcontrollers and Microprocessors (CPU):

These are the core "brains" of the PLC, executing the control program and managing inputs/outputs. Examples of general microcontrollers used in industrial applications might be from vendors like Analog Devices or feature in systems like the Siemens S7 series.

2. Memory Chips:

PLCs use various forms of memory (RAM, ROM, EEPROM) to store the operating system, the user's program, and current data/variables.

3. Data Conversion ICs:

For handling analog signals (e.g., from temperature or pressure sensors), specialized Analog-to-Digital (ADC) and Digital-to-Analog (DAC) converter ICs are used. Examples include the Analog Devices AD779x or AD773x families.

- Communication Interface ICs:
These chips manage communication with other devices and networks using protocols like RS-232, RS-485, or Ethernet.
- Digital Logic ICs (General Purpose):
While the main logic is software, general-purpose logic ICs (like buffers, decoders, etc.) might be used in the I/O modules and other support circuitry.
- Classic Digital Logic IC Numbers:
The 7400 series is a common family of Transistor-Transistor Logic (TTL) ICs containing basic logic gates, which are used in general digital circuits, but typically not the primary means of logic implementation within a modern programmable logic controller's core CPU.
- Common 7400-series ICs include:
7400: Quad 2-input NAND gate.
7402: Quad 2-input NOR gate.
7404: Hex inverter (NOT gate).
7408: Quad 2-input AND gate.
7432: Quad 2-input OR gate.
7486: Quad 2-input XOR gate.

Note:
NAND and NOR gates are known as "universal gates" because any other type of logic gate can be constructed from them.

- Primary IC technologies:
Logic gate ICs are primarily manufactured using one of two technologies, each with different performance characteristics.
1.TTL (Transistor-Transistor Logic):
These ICs use bipolar junction transistors and deliver robust signal levels and fast switching speeds. The 7400 series originally used this technology and typically operates on a +5V power supply.
2. CMOS (Complementary Metal-Oxide-Semiconductor):
These ICs are built with MOSFETs. They offer lower power consumption and higher noise immunity, making them ideal for battery-powered devices. The 4000 series and modern versions of the 7400 series use CMOS technology.

In a PLC, the functionality of these physical gates is replicated in the PLC's software using programming languages such as ladder logic, function block diagrams, or structured text, which adhere to the IEC 61131-3 standard. The user defines the logic, which is then compiled and run by the PLC's internal processor.

- A Programmable Logic Controller (PLC) The brain of industrial automation

https://archive.org/details/a-programmable-logic-controller-plc

By: Haytham Zeidan

https://archive.org/details/@wazefapress

Resources:

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